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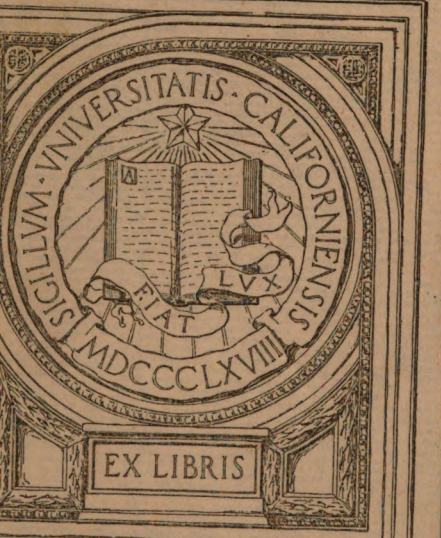

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APPLICATION AND MAINTENANCE OF CHARCOAL IRON BOILER TUBES

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RECOMMENDED PRACTICE

FOR THE

APPLICATION AND MAINTENANCE

OF

CHARCOAL IRON BOILER TUBES
ARCH TUBES
AND
SUPERHEATER FLUES

COMPILED BY

G. H. WOODROFFE

Mechanical Engineer, The Parkesburg Iron Company

and

C. E. LESTER

Formerly General Superintendent
19th Division, Transportation Corps, A. E. F.
and Superintendent of Nievre Locomotive and Car Shops

THE PARKESBURG IRON COMPANY

Genuine Charcoal Iron Boiler Tubes

Parkesburg, Pa.

New York Philadelphia Boston Chicago St. Louis
San Francisco St. Paul Montreal

EXPORT AGENTS

Wonham, Bates & Goode Trading Corporation, New York

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FOREWORD

In the 65,000 locomotives on American railroads; there are approximately 15,000,000 boiler tubes. Every year, 2,750,000 tubes pit, corrode or otherwise become unfit for service and have to be removed and replaced. All boiler tubes, even those giving satisfactory service, must be taken out, inspected, safe ended, reapplied or replaced after four years' continuous service.

The tube problem, an important one on any road, varies with feed water conditions and the service life of the tube used.

Feed water difficulties are local ones, met by individual study and various expedients.

Tube service life, while affected by feed water, depends largely on:

Character and quality of the tube itself.
Degree of care and skill with which the tube is applied and maintained.

Of the ferrous materials employed in boiler tube manufacture, charcoal iron is conceded to have the greatest resistance to corrosion and pitting. Charcoal iron is the purest of commercial wrought irons. It is fibrous, ductile, extremely weldable. It contains minute cinder and slag particles not found in other boiler tube materials. These inclusions tend to arrest the spread of corrosion and considerably prolong the useful life of the tube.

Charcoal iron tubes, because of these inherent advantages, give longer initial service, fre-

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quently running the full four-year period and can be safe ended repeatedly. They last longer in bad water districts and give proportionately greater service when feed water is favorable. The charcoal iron boiler tube reduces boiler work and cuts down shop costs.

Parkesburg Charcoal Iron Boiler Tubes are made of genuine charcoal iron. Behind them are fifty years of iron-making knowledge, skill and experience. For thirty-six years Parkesburg Charcoal Iron went into the making of the Allison boiler tube, long the standard on American railroads.

There is a correct way to apply a boiler tube, and an incorrect way. With certain tools the necessary operations may be performed efficiently, with minimum time and labor costs. Done with tools less suited to the work, the application is not only unsatisfactory, but the service life of the tube is materially shortened.

In the interest of better tube service and lower tube costs we have prepared this "Recommended Practice for the Application and Maintenance of Charcoal Iron Boiler Tubes, Arch Tubes and Superheater Flues." From the standard practices of a number of railroads we have taken what we believe to be the best and have incorporated it in this recommended practice. In this work we have been guided by the suggestions and recommendations of practical railroad men whose cheerful assistance and valuable co-operation are gratefully acknowledged.

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A word about tube costs. A little thought will show the futility of trying to reduce tube costs by buying inferior tubes of lower first cost. Charcoal iron boiler tubes, being largely hand-made, necessarily cost more than tubes made under tonnage methods. The ultimate economy of the charcoal iron tube lies in its long service life. The charcoal iron tube stays in the boiler.

As a step in the direction of lower tube costs, re-tube some of your locomotives with Parkesburg Charcoal Iron Boiler Tubes. Follow the standard practice suggested in this book. Compare the tube service. You will find that charcoal iron boiler tubes help to bring tube costs down and keep them down.

THE PARKESBURG IRON COMPANY

Parkesburg, Pa.
May 1, 1922.

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APPLICATION

Methods of applying boiler tubes and the tools employed, vary considerably on the different railroads.

Whatever the procedure:

The various operations must be performed with care and thoroughness.

The tools used must be properly maintained.

Tubes should be made tight in the flue sheet with the least possible working. Once a tube is really tight, excessive working will not make it more secure. On the contrary, it will injure the metal and adversely affect the service life of the tube.

The roller expander is not recommended for use on the firebox end of tubes except possibly for a light finishing hand operation. The roller crushes the metal of the tube, thinning it out and reducing its resistance to the demands imposed by service.

The word tubes, as used in the following pages, refers to body tubes. By flues are meant the large "tubes" containing the superheater unit pipes.

APPLICATION OF BODY TUBES

PREPARATION OF BACK TUBE SHEETS

Holes for body tubes in the back tube sheet should be the same diameter as the nominal outside diameter of the tube, both edges being rounded to a radius of 1/16".

PREPARATION OF FRONT TUBE SHEETS

Holes in front tube sheet should be 1/16" larger than the nominal outside diameter of tube

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except that two holes, 5/16" larger than the outside diameter of tube should be left about 12" above the bottom row of tubes in the center, in order to facilitate the removal of badly scaled tubes. All holes should be clean and the outside edges rounded to a radius of 1/16".

COPPER FERRULES

Ferrules for all boiler tubes should be soft copper, 1/32" longer than thickness of the back tube sheet.

Ferrules must be of the same outside diameter as tube and should be .0625 (1/16"), .08" and .09" thick. For new work, ferrules should be 1/16" thick, the heavier copper being used after tube holes have become enlarged through service. This practice permits the use of a standard swage. Copper ferrules may be softened by annealing before use.

REAMING TUBE HOLES

When a back tube sheet hole becomes 1/8" out of round, ream it with a straight reamer. When it becomes enlarged through service to 3/16" above outside diameter of tube, remove the sheet and scrap it.

PREPARATION OF FIREBOX END OF TUBES

Swage the firebox end of tube with a slight taper, to 1/8" less than the nominal outside diameter of tube, so that it will drive snugly in ferrule, after ferrule has been tightened in the sheet. Length of swaged end should be thickness of tube sheet plus 1/4".

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PREPARATION OF SMOKEBOX END OF TUBES

Cut tubes to length. The smokebox ends should be expanded hot, to such a size that when placed in boiler they can be driven snug in the front tube sheet. This should not be done to tubes that are to be transferred (put in through one hole and set in a different location) in the boiler.

The ends of the two tubes that are to be placed in the enlarged holes may either be expanded hot to the required size or have a piece of tube of larger diameter, 12″ long, welded on.

OPERATION NO. 1—*Setting Ferrules*

Place ferrules in tube holes in firebox sheet, 1/32″ in from fire side. Tighten with straight sectional expander (Fig. 1), or roll with roller expander.

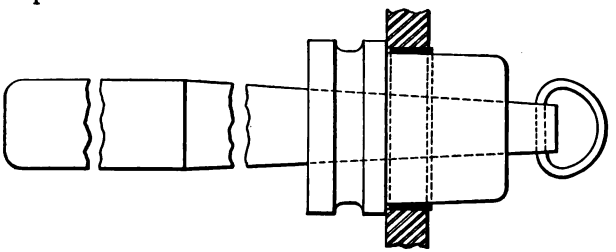

FIGURE 1
Setting Copper Ferrule in Tube Sheet

OPERATION NO. 2—*Placing Tubes*

Clean firebox ends of tubes, and place in tube holes in back tube sheet, fitting them neatly into copper ferrules.

Be careful not to injure or displace ferrules.

Tubes should project through back tube sheet 3/16″, as measured by gauge. (See Fig. 2.) The

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projection through front tube sheet should b
1/4". It should not be less than 1/8" nor more tha
3/8".

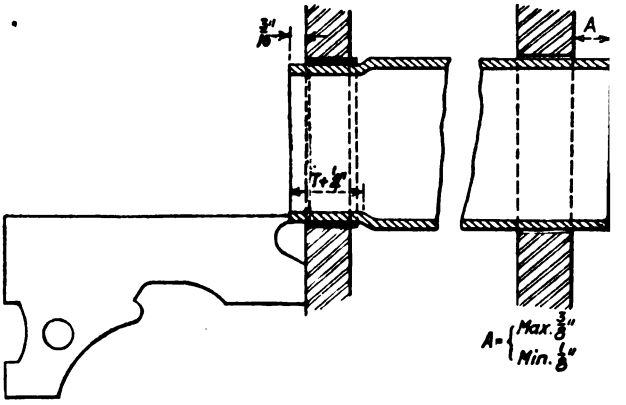

FIGURE 2
Proper Position of Tube in Sheet

OPERATION NO. 3

Tightening Tube in Sheet

Tighten tubes in back tube sheet with a straight sectional expander. (See Fig. 3.)

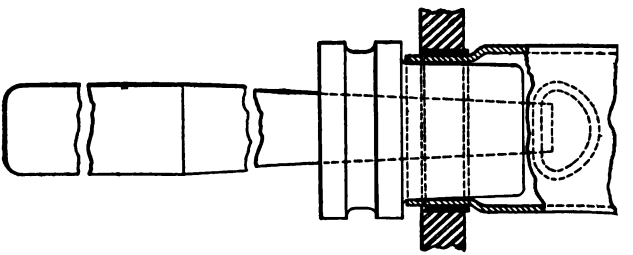

FIGURE 3
Tightening Tube in Back Tube Sheet

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OPERATION NO. 4

Tightening Front End of Tubes

Next, tighten front end of tube with a standard roller expander.

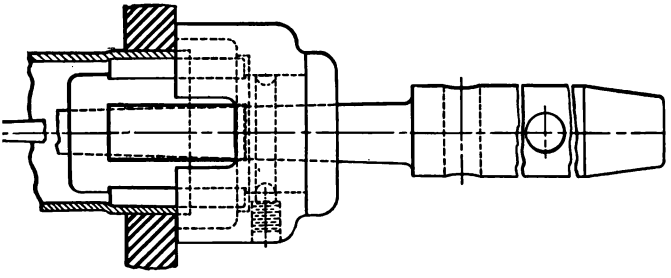

FIGURE 4
Rolling the Tube in the Front Tube Sheet

OPERATION NO. 5

Flaring Tubes, Preparatory to Beading

The back ends of all tubes and on super-heater engines, the front ends of the two rows of tubes just below the superheater flues and all tubes above these two rows, should be opened with a flaring tool (Fig. 5) using a long-stroke pneumatic hammer.

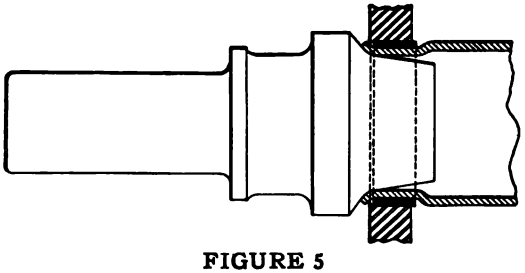

FIGURE 5
Flaring Tube

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OPERATION NO. 6

Expanding with Lipped Sectional Expander

Expand the firebox ends of tubes with lipped sectional expander shown in Fig. 6. Drive the expander pin lightly until it is fairly solid. Draw out pin. Give the expander a turn equal to half a section of the expander. Drive the pin a second time. Withdraw it, and turn expander a distance equal to one-quarter of a section. Drive the pin a third time. Care should be exercised in the use of the expander in the outer rows of tubes near the heel of the flange to avoid cracking the sheet. Use a long-stroke pneumatic hammer in driving the pin. Nothing heavier than a Boyer No. 60 or its equivalent, is recommended.

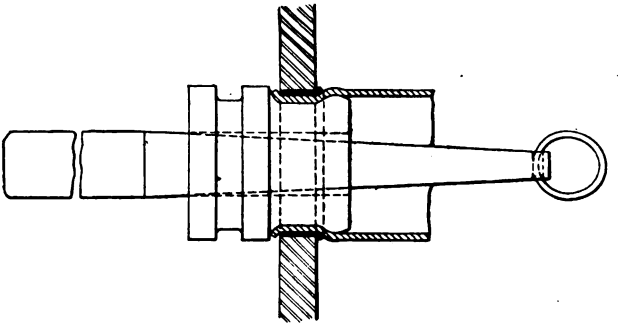

FIGURE 6

Lipped Sectional Expander Used to Expand the Firebox End of Tubes

INSPECTION FOR SPLIT TUBES

After expanding (Operation 6), examine tubes carefully. Those which have split in the shoulder formed by the lip of the expander, and tubes that have opened from the end into the sheet, should be removed and replaced before beading.

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OPERATION NO. 7

Opening Front End of Tubes That Have Not Been Expanded Hot

If front end of tube has not been opened hot before placing in boiler, a straight sectional expander should be used to tighten the tube in the sheet. The tube may then be rolled with a standard roller expander.

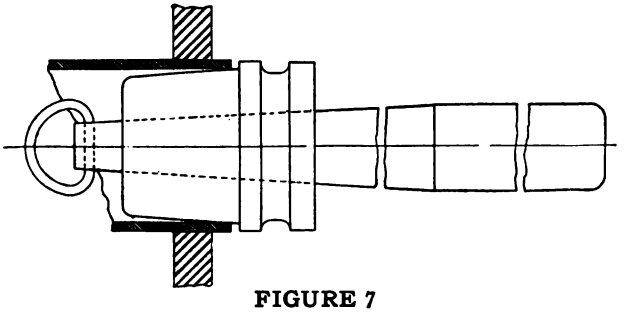

FIGURE 7

Tightening Tube with Straight Sectional Expander

If finger type roller expander (Fig. 8) is used, the use of the straight sectional expander is not required.

FIGURE 8

Finger Type Roller Expander

OPERATION NO. 8—*Beading*

Firebox ends of all tubes must be beaded. (Fig. 9.) Use a short-stroke pneumatic hammer. Take care that nothing enters between bead and tube sheet. In superheater locomotives the front ends of the two rows of tubes just below the bottom row of superheater flues and all tubes above these rows must be beaded similarly.

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Hold the beading tool so as to give the bead an outward set and get it down to the sheet without raising a burr on the inside or marking the outside of the sheet with the heel of the beading tool. The center line of the beading tool should always be inside the line of the tube. Remove, with a small chisel and hand hammer, any burrs that may be raised. If necessary, the back ends of tubes may be rolled lightly after beading.

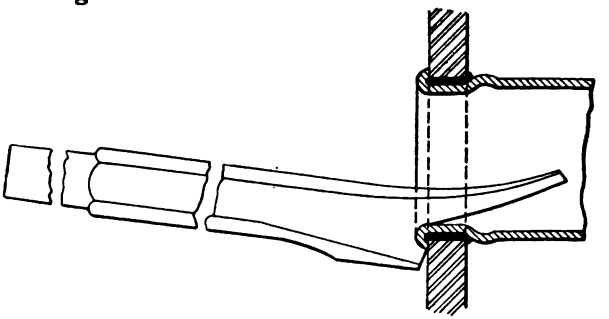

FIGURE 9
Beading Tubes

TOOLS

All beading tools must be maintained within the limits of standard gauges. Lipped expanders should be stamped to show thickness of the sheet on which they are to be used and should be taken out of service when worn or distorted to such an extent that they will not force the tube squarely against the sheet.

Application of Superheater Flues

PREPARATION OF BACK TUBE SHEET

Holes for superheater flues in back tube sheet should be 4 5/8" in diameter, both edges being rounded to a radius of 1/16".

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PREPARATION OF FRONT TUBE SHEET

Holes in front tube sheet should be 3/32" larger than nominal outside diameter of flue, and outside edges should be rounded to a radius of 1/16".

COPPER FERRULES

Ferrules must be made of soft copper, 1/32" longer than thickness of tube sheet. Ferrules must be of same outside diameter as the flue hole and should be .0625" (1/16"), .08" and .09" thick. For new work, use ferrules 1/16" thick, the heavier copper being used after holes become enlarged through service.

PREPARATION OF FIREBOX ENDS OF TUBES

Firebox ends of flues should be swaged to a diameter of 4½". The straight portion should be five inches (5") and the tapered portion three inches (3") long, as in Fig. 10. Remove all scale and burrs before placing ends in the tube sheet.

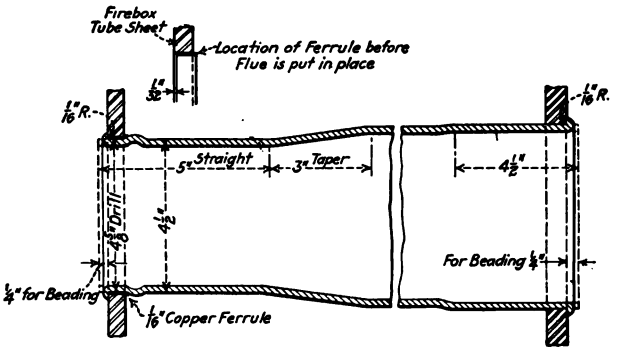

FIGURE 10
Correct Application of Superheater Flues

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PREPARATION OF SMOKEBOX END OF FLUES

Cut flue to length. Expand smokebox end, hot, to a diameter of 1/16″ greater than nominal outside diameter of flue, as in Fig. 10.

OPERATION NO. 1—*Setting Ferrules*

Place ferrules in flue holes in back tube sheet 1/32″ in from fire side and tighten with roller expander. (Fig. 11.)

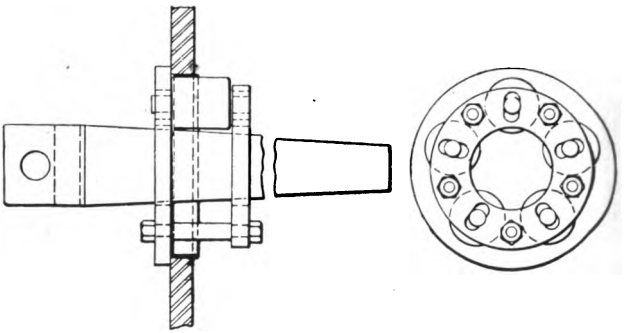

FIGURE 11
Setting Ferrules

OPERATION NO. 2—*Placing Flue*

Place flues in holes in back tube sheet, fitting them neatly into copper ferrules. Flues should project through both sheets ¼″ to allow for beading. (See Fig. 10.)

OPERATION NO. 3

Rolling Flue in Back Tube Sheet

Tighten flues in back tube sheet with roller expander. The roller expander shall have not less than five (5) rollers. (See Fig. 12.)

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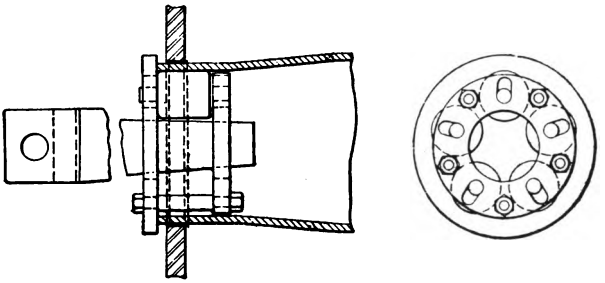

FIGURE 12
Tightening Superheater Flue with Roller Expander

OPERATION NO. 4

Flaring Flues in Back Tube Sheet

A flaring tool, because of its size and weight and the force necessary to drive it, is not recommended for superheater flues. Superheater flues should be flared by careful blows of a four-pound peining hammer.

OPERATION NO. 5

Expanding Flues in Back Tube Sheet

Expand back ends of flues with lipped sectional expander of not less than twelve (12) segments. (Fig. 13.) Drive expander pin until it is fairly solid. Draw out pin and give the expander a turn equal to one-half of a section of the expander. Drive pin a second time. Withdraw it. Turn expander a distance equal to one-quarter of a section. Drive the pin a third time. Use a long-stroke pneumatic hammer in driving the pin.

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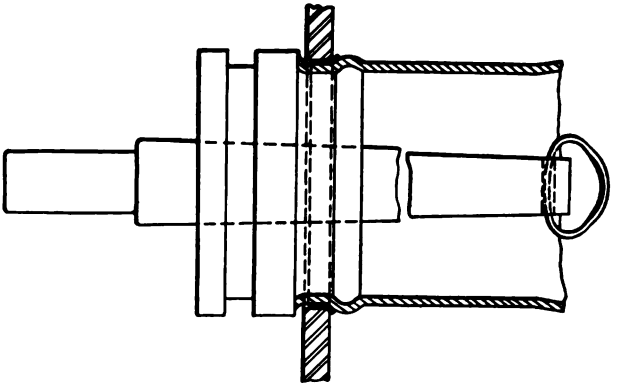

FIGURE 13
Expanding Flues

OPERATION NO. 6

Rolling Front Ends of Flues

Tighten front end of flues with a roller expander. (Fig. 14.)

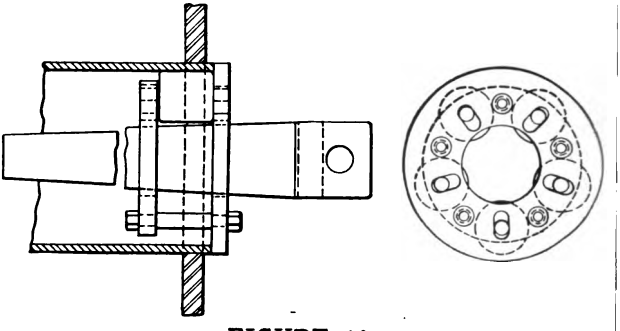

FIGURE 14
Rolling the Front End of Flues

OPERATION NO. 7

Flaring Front Ends of Flues

Follow instructions under Operation No. 4, page 17.

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OPERATION NO. 8

Beading Superheater Flues

Bead flues at both ends (Fig. 15) using a short-stroke pneumatic hammer. Take care to see that nothing enters between bead and sheet. Hold beading tool so as to give bead an outward set and get it down to the sheet without raising a burr on the inside or marking the sheet with heel of the tool on the outside. The center line of beading tool should always be inside the line of the tube. Remove, with small chisel and a hand hammer, any burrs that may be raised.

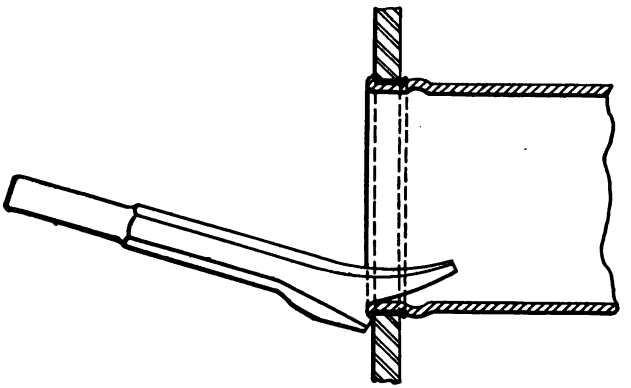

FIGURE 15
Beading Flues

TOOLS

All beading tools must be maintained within the limits of standard gauges. Lipped expanders should be stamped to show thickness of sheet on which they are to be used and should be taken out of service when worn or distorted to such an extent that they will not force the tube squarely against the sheet.

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APPLICATION OF ARCH TUBES

PREPARATION OF SHEETS

Sheets must be properly straightened. Holes for arch tubes must be circular and drilled 1/32" larger than outside diameter of the arch tube. Outside edges should be rounded to a radius of 1/16".

If the arch tube hole has become enlarged above normal size in service it should be trued up with a straight reamer and measured carefully, so that the tube can be heated and enlarged to fit the hole snugly before being applied. The use of shims or ferrules around arch tubes is not recommended.

PREPARATION OF ARCH TUBES FOR SETTING

Cut arch tubes to proper length with an allowance at either end for flaring. This allowance should be not more than 1/2" and not less than 3/8". They should be smooth on the ends and free from burrs. They should be formed in accordance with drawings for the various classes of locomotives. Particular attention should be given to bending, in order to prevent the formation of steam pockets in service due to improper bends, to make certain that the arch tubes enter the sheet at an angle of 90 degrees (Fig. 16), and to avoid flattening, which would not only weaken the tube but might cause an obstruction and prevent the turbine cleaner from going through.

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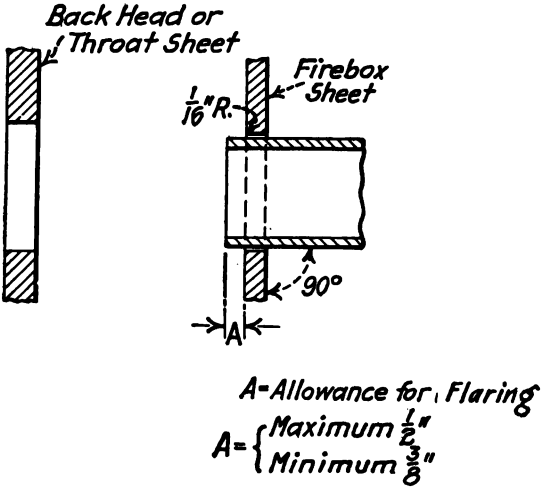

FIGURE 16
Proper Position of Arch Tubes Entering Firebox Sheet

SETTING OF ARCH TUBES

Arch tubes should be set in position, the proper amount projecting through the sheet for flaring and held with a clamp similar to Figure 17.

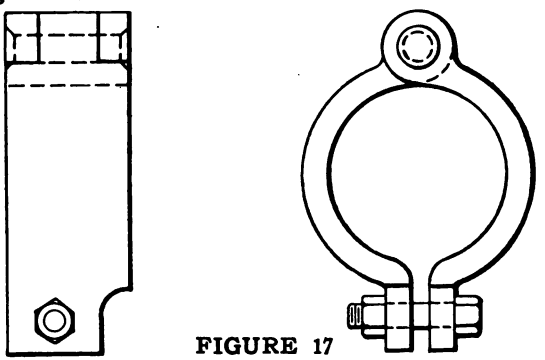

FIGURE 17
Arch Tube Clamp

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It is recommended that a spacing gauge (Fig. 18) be used to insure correct alignment of arch tubes.

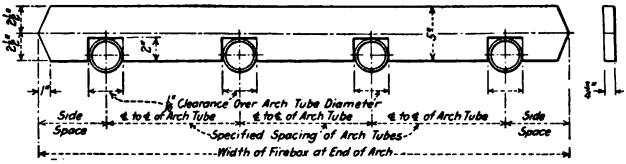
Clearance Over Arch Tube Diameter
Side Space
℄ to ℄ of Arch Tube
℄ to ℄ of Arch Tube
℄ to ℄ of Arch Tube
Side Space
Specified Spacing of Arch Tubes
Width of Firebox at End of Arch

FIGURE 18

ROLLING

Arch tubes should be rolled into firebox sheets, this operation being performed at lower end first. By using a collar on the housing shaft, as shown in Figure 19, proper location of the rolls can be insured.

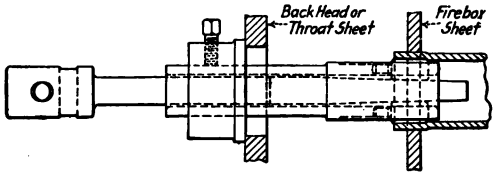

FIGURE 19

FLARING

Arch tubes should be flared on both ends. The tool shown in Figure 20 is recommended for this operation.

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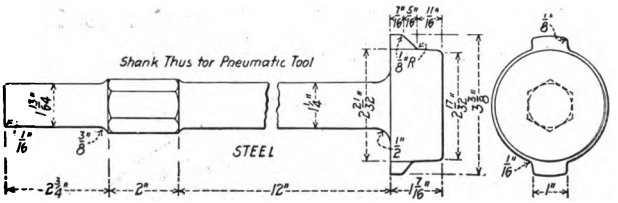

FIGURE 20

INSPECTION

When the engine is in service the arch tubes should be inspected every trip. At every boiler washout the arch tubes should be washed out, bored out with a turbine cleaner and the ends in the water space inspected.

At any time should an arch tube be found to have a pocket, or warped to any extent, the arch tube should be removed. Whenever a clinker or other substance is found attached to an arch tube the clinker should be removed and a careful inspection made of the outside and, whenever possible, the inside of the tube.

WELDING

The growing practice of electrically welding tubes and flues to back tube sheets, saves a great deal of boiler trouble and maintenance work. However, welding alone will not hold carelessly set tubes and flues. Each operation should be carried out as carefully and thoroughly as though no welding were to be done.

The metal of the weld is somewhat brittle and may be porous (Plate 1) on account of tiny blow holes that form as the metal solidifies from the molten state. The welding metal alone,

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therefore, cannot be depended upon to hold the tube in place or prevent leakage.

PLATE 1

Section of one of the welds shown in Plate 2, magnified fifteen (15) times to show blowholes in welding metal.

By uniting the bead to the sheet, however, the weld furnishes the strength and stiffness necessary to hold the shoulder of the tube against the ferrule, just as it was left by the expanding tool, and may also be dense enough to prevent a loosened tube from leaking in an emergency.

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PLATE 2

A good example of electrical welding. The 2¼" Parkesburg Charcoal Iron Boiler Tubes, set and welded in a ½" tube sheet, have been cut through and etched to show the weld.

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Recommended Practice for Electrically Welding Firebox Ends of Tubes to Sheets

SETTING TUBES AND FLUES FOR WELDING

Expand, roll and bead as described previously, using no lubricant on the setting tools. If it is felt necessary to use a lubricant, the following Corn Oil Soap has been found to be satisfactory and is said not to affect the welding:

In a steel drum or tank of about 60 gallons capacity, place:

20 gallons of water
15 pounds of lye (caustic soda)
10 gallons of pure corn oil

Boil from 6 to 8 hours, adding from 15 to 20 gallons of water to keep mixture from boiling over. At the end of this time the solution should be clear, indicating complete saponification. If not, continue boiling until mixture is clear. The resulting soap should be light amber in color and of about the consistency of vaseline.

PREPARATION

After tubes and flues have been tightened by expanding or rolling, but before they are beaded, the sheet should be thoroughly cleaned by sandblasting. The boiler should then be filled with warm water and tubes made perfectly tight before beading. If tubes are already beaded (locomotives taken out of service to have tubes welded) they should be made perfectly tight before welding.

The welding operation should be performed with warm water in the boiler and after the tubes or flues have been properly beaded.

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WELDING

Begin with the top row and work downward, welding superheater flues first. Each tube and flue should be welded by starting near the bottom, welding first up one side, then up the other, completing the weld near the top center. (See Fig. 21.)

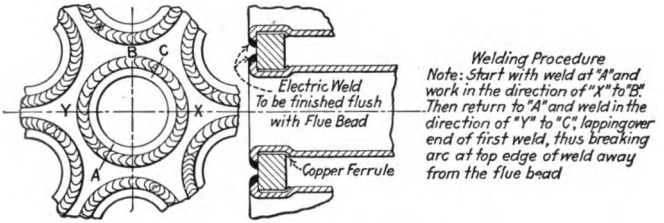
B
C
Y
X
A
Electric Weld
To be finished flush
with Flue Bead
Copper Ferrule
Welding Procedure
Note: Start with weld at "A" and work in the direction of "X" to "B". Then return to "A" and weld in the direction of "Y" to "C", lapping over end of first weld, thus breaking arc at top edge of weld away from the flue bead

FIGURE 21

REMOVING WELDING DEPOSIT

During the welding operation a deposit will form on the sheet and beads adjacent to the bead being welded. Carefully remove this deposit with a wire brush before starting to weld.

MAINTENANCE

Recommended Engine House Practice

GENERAL SUGGESTIONS

Tubes should be made tight in the sheets with the least possible amount of working. Excessive working shortens the life of tubes and flues.

Roller expanders, particularly when driven by air motor should not be used on the back ends of tubes. They distort the metal, weaken the tube, raise the bead slightly from the sheet, and not

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only shorten the life of the tube, but enlarge the tube holes in the sheet.

If necessary, new or safe ended tubes may be lightly rolled by hand, after beading.

REMOVING TUBES

Tubes should be taken out at the front end, through their respective holes. If their condition is such that this is impossible, remove them through the large holes near the bottom of the front tube sheet.

The dangerous practice of enlarging holes in the back tube sheet for the removal of tubes should not be permitted.

TUBES LEAKING SLIGHTLY

With a standard beading tool, lightly set the beads down to the sheet. Trim off the burrs with a chisel. If necessary to expand a tube, use a straight sectional expander with a light pneumatic or a four-pound hand hammer. The tube should then be beaded lightly.

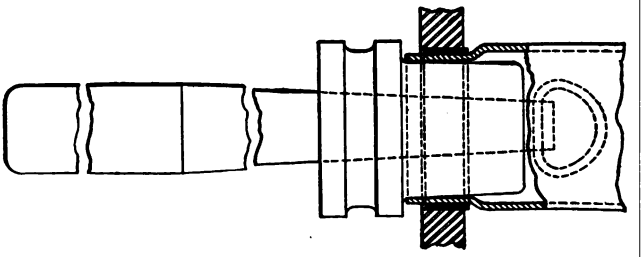

FIGURE 22
Tightening Tube in Back Tube Sheet

The use of the lipped sectional expander while boiler is under pressure is a dangerous practice that should not be permitted.

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TUBES LEAKING SERIOUSLY

When a locomotive arrives at the engine house with tubes that are leaking badly, draw the fire and drain the boiler. Reset tubes with standard lipped sectional expander (Fig. 23). Reset beads with standard beading tool. Remove, with a small chisel and hand hammer, any burrs that may be raised.

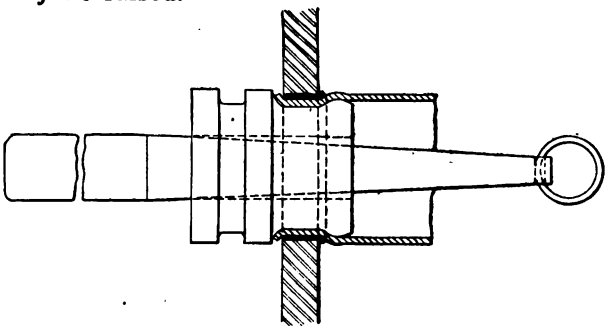

FIGURE 23

Lipped Sectional Expander Used to Expand the Firebox End of Tubes

WASH OUT PERIOD

At wash out period, reset tubes with standard lipped sectional expander. Set down beads with standard beading tool, using a light pneumatic hammer. Trim off all burrs, using a small chisel and a hand hammer.

ELECTRICALLY WELDED TUBES

RUNNING REPAIRS

Electrically welded tubes, leaking through "pin holes" in the weld, may be caulked with fuller and hand hammer. The pein of a hammer or a beading tool must not be used.

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If leak is under the weld, cut off the defective portion of the weld, reset tube with a lipped sectional expander, bead down, clean and reweld. If welding facilities are not available, expand the tube with a straight sectional expander. Rewelding should be done at first opportunity.

WASH OUT PERIOD

At the wash out period, and before steam is blown, carefully inspect all tubes and flues. Proceed with necessary work when boiler has cooled.

FLUE SHOP PRACTICE

By flue shop is meant that part of the plant in which tubes, removed from boilers after a period of service, are cleaned, cut off, safe ended and stocked for future use, and where new or reclaimed tubes are swaged and expanded for application.

FLUE SHOP EQUIPMENT AND LAYOUT

Flue shop equipment and layout are seldom given the consideration which they merit. Too often, flue shop machinery is obsolete or inadequate, and poorly arranged. A careful study of almost any shop layout will open up new ways of saving time and money. Up-to-date, economical flue shop equipment, which can be purchased and installed at a moderate outlay, will save its initial cost in a short time.

The railroad flue shop shown in Figure 24, handles 500 boiler tubes and superheater flues per day at an exceedingly low cost. The work progresses in one direction only—forward. Specially designed cradle trucks are used.

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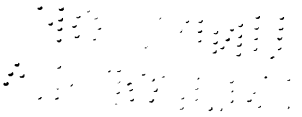

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Machines have been so arranged as to make it unnecessary to turn tubes end for end. The use of an overhead crane, though not essential, will further reduce the handling cost. This layout, varied slightly to meet individual conditions, is followed in a number of shops throughout the country.

CLEANING TUBES

There are three general types of tube cleaners: (1) rotary single tube cleaner; (2) dry rattler; (3) wet rattler.

The small shop, handling comparatively few tubes a day, may find the rotary single tube cleaner sufficient for its needs. Where a considerable number of tubes have to be handled, dry rattlers and wet rattlers are used.

WEIGHING CLEANED TUBES

After cleaning, tubes should be weighed, and those below definite, limiting weights should be scrapped. This practice has two advantages: it saves good material that might otherwise be discarded, and it goes far toward eliminating tube failures on the road by weeding out worn, under-gauge tubes.

TABLE 1
MINIMUM WEIGHTS

Diameter of Tube	Gauge of New Tube	Service	Weight per Foot	
			Pounds	Ounces
2″	11	Locomotive	1	11
2¼″	11	"	1	15
2½″	11	"	2	3
3″	12	Stationary	2	11
3½″	11	"	3	14
4″	10	"	4	12
5⅜″	9	Locomotive Superheater	6	11
5½″	9	"	7	00

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HEATING FOR SAFE ENDING, SWAGING AND EXPANDING

For proper safe ending, swaging and expanding, tubes must be heated quickly, evenly and thoroughly. The heating furnace, whether coke-burning, gas or oil-fired, should have sufficient brick work to absorb heat from the fuel and radiate it to the work.

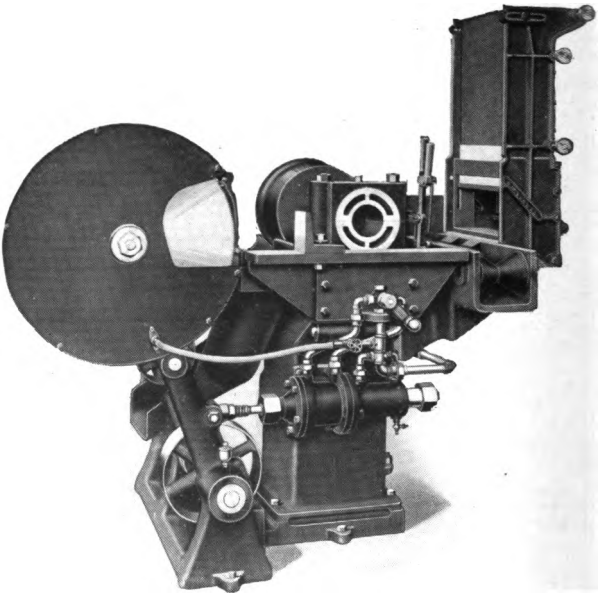

PLATE 3
(Combination Hot Saw and Expander)

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CUTTING OFF TUBES

Of the many types of tools used for cutting off tubes, the hot saw is perhaps the best. It cuts quickly, uses little power and leaves only a small burr which is easily removed while the metal is hot.

A hot saw and expander, mounted on the same housing, are shown in Plate 3. This machine eliminates one handling of the tube, which can be cut and expanded at one heat and safe ended after a quick wash heat.

FLUE WELDING MACHINE

Good results may be obtained with welders of either the roller or hammer type. A little care and the right kind of mandrel will minimize or entirely eliminate the ridge that is often left inside the tube.

ELECTRIC SAFE ENDING

Where cheap electrical power is available, the question of safe end welding electrically should be studied carefully. The operation is quick and the welds are excellent.

A heavy, low voltage current is passed through the safe end and the end of a boiler tube or a superheater flue. The two pieces are held in contact by pressure. The electrical energy is transformed into heat and the junction of the tube and safe end soon becomes white hot, fusing or welding the two pieces together. The current is then shut off, contact clamps released and the joint smoothed and rolled down to the normal tube diameter in a roller welder.

SWAGING AND EXPANDING

To facilitate insertion and removal of locomotive boiler tubes, tube holes in the front sheet

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are made slightly larger than the nominal outside diameter of the tube. The front ends of the tubes, therefore, have to be expanded for a tight fit.

Tube holes in the back tube sheet are the same size or slightly smaller than the nominal outside diameter of the tube. With a copper ferrule in the tube hole, it is necessary to swage the firebox end of the tube, reducing its diameter.

Swaging is always done hot. Tubes are usually heated for expanding.

With the use of the equipment and the arrangement suggested, safe end welding can be finished quickly enough to permit swaging (or expanding) at this heat. A slower process, however, may necessitate a quick "wash heat" after welding and before swaging or expanding.

The charcoal iron boiler tube has a critical range, approximately 1550 to 1750 degrees Fahrenheit and swaging and expanding should be done above this temperature.

Temperature determination by color is misleading and unsatisfactory but in this particular case if the work is kept above an orange color, failures will be avoided. (Plate 4).

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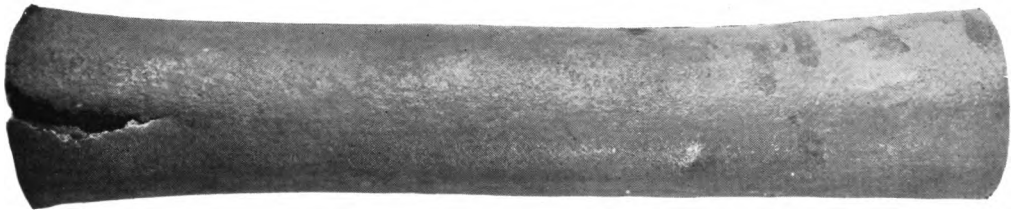
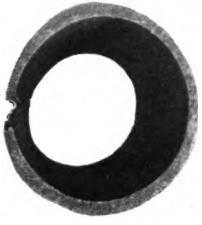


A



B

PLATE 4

One end of the short piece of charcoal iron tube was expanded while the tube was passing through the critical range. The other end was given even more expansion at a temperature above this range. The perfect result on the end marked "B" would have been duplicated on "A," had the end "A" been expanded at a temperature above or below the critical range.

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TUBE TESTING

The removal of tubes that leak under the hydrostatic test of the boiler, causes delay and is expensive; therefore we believe it to be good practice to test all safe ended tubes before putting them into the boiler. The test pressure should be 25 per cent. in excess of the boiler working pressure, and while under the test pressure the tubes should be struck near the safe end weld or welds with a two-pound steel hand hammer or the equivalent.

One type of tube testing machine is shown in Plate 5.

Safe Ending Practice and Number and Length of Safe Ends

Tubes, which on examination after cleaning are found to be pitted or worn one-third of the original thickness of the tube, should be scrapped.

If the pitted or worn surface is not too great, it may be cut off and the good portion of the tube used in boilers having shorter tubes.

When tubes, otherwise good, have been reduced in weight below the limits given in the following table, they should be discarded.

MINIMUM WEIGHTS

Diameter of Tube	Gauge of New Tube	Service	Weight per Foot	
			Pounds	Ounces
2″	11	Locomotive	1	11
2¼″	11	"	1	15
2½″	11	"	2	3
3″	12	Stationary	2	11
3½″	11	"	3	14
4″	10	"	4	12
5⅜″	9	Locomotive Superheater	6	11
5½″	9	"	7	00

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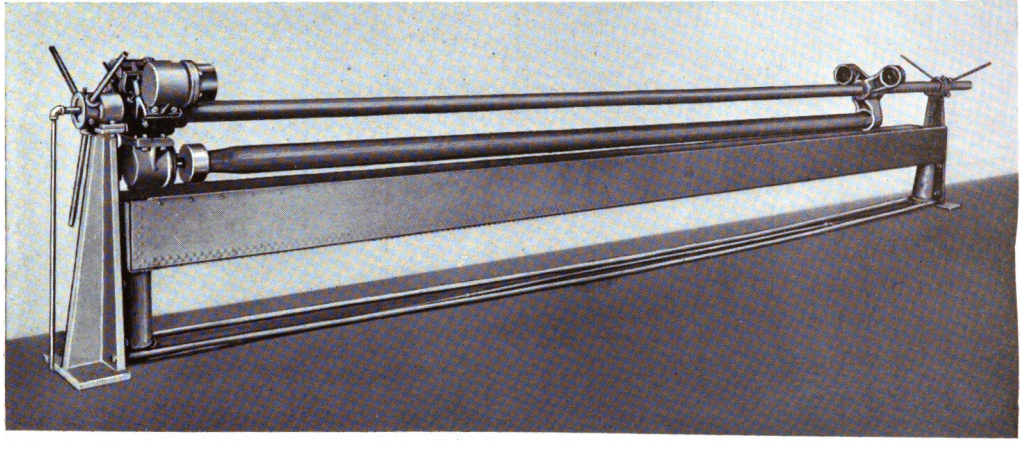

PLATE 5

One Type of Tube-Testing Machine

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Tubes that are slightly pitted or otherwise weakened, but which are still serviceable, should be kept together and reapplied in sets of tubes which are in approximately the same condition.

SAFE ENDING

Good tubes should be safe ended as follows:

Safe ends should be scarfed on one end for ½" (see Fig. 25), being tapered to 1/32" at end of scarfing.

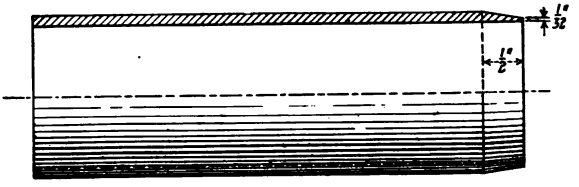

FIGURE 25

Recommended Method of Preparing Safe Ends for Use

Tubes to be safe ended should be expanded for scarfed end of safe end, so that they will fit snugly.

Place safe end in end of tube. Heat both to a welding heat. Draw out and quickly weld, on the flue welding machine, taking care to see that the weld is smoothly made.

SUCCESSIVE SAFE ENDING

It is recommended that body tubes contain not more than three welds at one time, with a total length of welded ends not to exceed 21". If the total length of welds exceeds 21", all welds should be cut off, and one piece of the tube welded on to bring the length up to requirement. To this a new 5" safe end should be added at the firebox end at the first safe ending. Thereafter the following table should govern.

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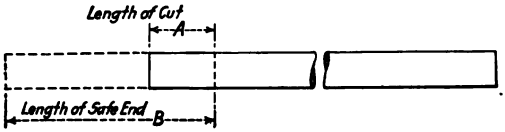
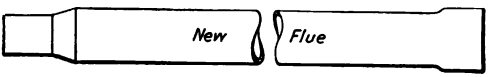


FIGURE 26

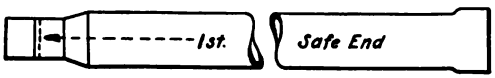
	Length of Cut A	Length of End B	Remarks
First Application.....			New Flue
Second Application....	1½"	5	One Weld
Third Application.....	5½"	8	" "
Fourth Application....	8½"	11	" "
Fifth Application.....	11½"	14	" "
Sixth Application.....	1½"	5	Two Welds
Seventh Application...	5½"	8	" "
Eighth Application....	8½"	11	" "
Ninth Application.....	27½"	30	" "
Tenth Application.....	1½"	5	Three Welds

Superheater flues should not contain more than two welds. The use of a safe end shorter than 5" is not recommended.

FIGURE 27



First application. New flue.



Second application. Cut swaged end to 3½" and apply 5" safe end, cutting to length after welding.

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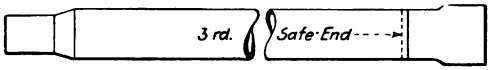
Third application. Cut swaged end to 2½" and apply safe end just long enough to give required length.



Fourth application. Cut off previous weld and reswage end to original dimensions. Apply safe end of full diameter at smokebox end, just long enough to give required length. Expand to standard requirements.

Fifth application. Same as second.

Sixth application. Same as third.

Seventh application. Same as fourth, except that old safe end at smokebox end of the flue should be cut off and a longer safe end used.

Suggestions in Connection with the Ordering, Unloading and Storing of Tubes

ORDERING

Requisitions or orders for boiler tubes, arch tubes, superheater flues and safe ends, for new work or replacements, should clearly state:

Length.....in feet or inches.
Outside diameter..in inches.
Thickness.....in B.W.G. number, or in decimals of an inch.

The thickness of heavy wall tubes, such as arch tubes, water bars and marine stay tubes is

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often expressed in fractions of an inch: 3/16", 1/4", etc.

TABLE II

Decimal Equivalents of Birmingham Wire Gauge (B.W.G.) Numbers Used in Boiler Tube Practice

THICKNESS
BIRMINGHAM WIRE GAUGE

Number	Inches
13	0.095
12	0.109
11	0.120
10	0.134
9	0.148
8	0.165
7	0.180
6	0.203
5	0.220

If tubes or flues are to be swaged or expanded, the fact should be stated on the order, and a blue print or sketch furnished to the tube manufacturer. Heavy tubes for special purposes may have the ends upset and enlarged within certain limits. When such work is to be done by the manufacturer, blue print or sketch should accompany the order.

LENGTH

Tubes for locomotive type boilers should be ordered one (1") inch longer and flues for locomotives superheater service one and one-half (1½") inches longer than the actual distance between the outer sides of the tube sheets to allow for flaring and beading and irregularities in the tube sheets.

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Wherever possible measure carefully the actual distance between tube sheets. In new work, variation of 1/4" to 1/2" may be found in the tube sheets of locomotives and horizontal return tubular boilers, due to distortion in manufacture. On boilers that have been in service, particularly locomotive boilers, bulging of the tube sheets may cause variations of an inch or more.

SAFE ENDS

Buying safe ends cut to length is a costly practice, necessitating as it does, large stocks of various sizes. It is more economical and satisfactory to purchase tubes in random lengths, cutting the safe ends as required. A good safe end machine will cut and scarf 120 safe ends per hour with a low labor cost.

SCARFING OF SAFE ENDS

Opinions differ as to the amount of scarf required to give the best results. Our suggestion is that safe ends be scarfed for a distance of 1/2", the metal tapering to a thickness of 1/32". (See Fig. 25, page 38.)

UNLOADING AND STORING

Tubes should be unloaded with care and placed under cover at once, the various sizes in separate racks. The ends of the tubes, if exposed to the weather, should be sprayed or coated with oil. Refuse lubricating oil answers the purpose at very little cost.

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Remedying Conditions Responsible for Tube Maintenance Work

A great deal of tube and flue repairs are due to:

Faulty application of tubes and flues.

Lack of standardization of tube-setting tools, or tools of poor design.

Too many safe ends on tubes or flues at one time.

Poor workmanship in safe ending.

Continuance of tubes in service after they have become thin and worn out.

Tubes stopped up.

Abuse by careless or unskilled hot workers.

Cooling boiler too rapidly by injector, and improper use of blower.

Cooling too rapidly by blowing down for wash out.

Washing out hot boilers with cold water.

Lack of proper attention at wash out period.

Delayed wash out in bad water districts.

Firing up rapidly and raising steam too quickly in engine house.

Allowing fire to die next to tube sheet while locomotive is standing in engine house or yard.

Most of these conditions can be improved, if not corrected entirely, by the mechanical department. Defective or inferior material, bad fuel, impure feed water, poor boiler design

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and conditions beyond the control of the mechanical department, may frequently be bettered as a result of constructive suggestions to the responsible departments.

IMPORTANCE OF RECORDING BOILER TUBE SERVICE

Recording the service life of tubes in locomotives running hundreds of miles every day, and handled by two or more shops, admittedly presents difficulties, but an accurate and systematic record of tube service is absolutely essential if tube costs are to be reduced.

A suggested form for recording the service of a set of tubes is shown in Figure 28.

Careful study of conditions disclosed by worth-while records, together with modern flue shops, standardized tools, and a generally adopted standard practice for setting and maintenance, would reduce the tube costs of American railroads by many thousands of dollars.

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RECORD OF FLUES															
	BODY FLUES							SERVICE		SAFE ENDS			SERVICE		
SHOP	APPLIED TO LOCO. NO.	REMOVED FROM LOCO. NO.	APP. NO.	NAME	MTL.	NUMBER	DATE APPLIED	MILES	MONTH	NAME	MTL.	DATE APPLIED	MILES	MONTH	REMARKS

FIGURE 28

Suggested Form for Recording Service of a Set of Locomotive Boiler Tubes

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THIS BOOK IS DUE ON THE LAST DATE
STAMPED BELOW

AN INITIAL FINE OF 25 CENTS
WILL BE ASSESSED FOR FAILURE TO RETURN
THIS BOOK ON THE DATE DUE. THE PENALTY
WILL INCREASE TO 50 CENTS ON THE FOURTH
DAY AND TO $1.00 ON THE SEVENTH DAY
OVERDUE.

DEC 26 1934

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